APPENDIX A

U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco, California 94135

NRDL 5100.10A
730
8 December 1966

NRDL INSTRUCTION 5100.10A

From: Commanding Officer and Director
To: Distribution List C

Subj: Radiological Safety

Ref: (a) NRDLINST P5100.11, Radiological Safety Manual, NRDL
(b) Radiation Health Protection Manual, NAVMED P-5055
(c) Title 10, Code of Federal Regulations

1. Purpose. To restate the program of radiological health and safety in Laboratory operations, and to redefine responsibilities for its effective implementation.

2. Cancellation. This Instruction cancels NRDLINST 5100.10 and Supplements 1 and 2, NRDLNOTE 5100 of 24 August 1966 and NRDLINST 5100.1.

3. Scope. The radiological safety program applies to operations in all work areas under Laboratory control, including field locations. The program will consist of

(1) training and indoctrination,
(2) environmental monitoring,
(3) personnel monitoring,
(4) contamination control measures and protective equipment usage,
(5) medical examinations, and
(6) accountability and control of radioactive materials.

The program does not apply to hazard situations associated with nuclear weapons.

4. Policy. The serious nature of radiation hazards calls for the most scrupulous observance of precautions. It is Laboratory policy that exposure to ionizing radiation be permitted only in cases of valid necessity and that it be held to a minimal level.

5. Licensing and Control. It is essential that all personnel be made aware that this Laboratory's use of radiation sources is subject to licensing, control and inspection by the U. S. Atomic Energy Commission. Compliance with all provisions of the license is therefore a necessity.

6. Responsibilities.

a. Technical Division Heads. The Head of each Technical Division shall be responsible for the effective dissemination of radiological safety rules and regulations within his division, for making personnel available at reasonable times for radiological safety training and instruction, and for overall safety of operations in work areas assigned his division.

b. Technical Investigator. Each technical investigator using radiation sources will be responsible for strict observance of prescribed rules of radiological safety, as applicable both to personnel and to visitors, in work areas assigned to him.

c. Health Physics Division. The Head of the Health Physics Division (Code 730) shall serve as Radiological Safety Officer for the Laboratory, with responsibility for supervising the execution of the radiological safety program. Code 730 will provide consultation as needed in the implementation of controls for the hazards associated with radiation sources and the effectiveness of these control measures.

d. Radiological Medical Director. The Radiological Medical Director (Code 700) will supervise the combined radiological health and safety program and continuously advise the Commanding Officer and Director (Code 100) with regard to its effectiveness.

e. Radiological Safety Committee. The Radiological Safety Committee shall, in advance of purchase, review and approve proposals for use of radioisotopes and irradiation services. In addition, this Committee will serve as a review board in cases of excessive exposure or hazards.

7. Radiological Safety Manual. The rules of radiological health and safety in NRDL operations will be found in reference (a), which is based on references (b) and (c). References (b) and (c) are available in Code 730 for examination by any NRDL member.

D. C. [illegible]

NRDLINST. P5100.11
December 1966

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
RADIOLOGICAL SAFETY MANUAL

Prepared by
Health Physics Division
U.S. Naval Radiological Defense Laboratory
San Francisco, California 94135

EMERGENCIES

(Where there is radioactive material)

1. NOTIFICATION

a. Contamination:	Health Physics Division	Ext. 240
b. Injuries:	Radiological Health Officer	Ext. 235
c. Fire:	Telephone Operator	Ext. "0"

After Normal Working Hours -- First inform Laboratory Duty Officer, Extension 318, who will in turn notify proper Departments.

2. PERSONAL DECONTAMINATION

a. Contaminated Wounds. Flush the wound under cold running water and await the arrival of the Radiological Health Officer.

b. Contaminated Skin. Wash the skin with soap and water, taking care not to spread contamination to clean area. Further instructions will be given by the Radiological Health Officer and the Health Physicist. Skin decontamination kits are located in Rooms 2179 and 218, respectively in Building 815.

3. FIRE IN RADIOACTIVE AREAS

Evacuate area immediately. Notify telephone operator or Extension 318, specifically stating that the fire involves radioactive material. Re-entry into the area shall be made only by fire fighting personnel. The Health Physicist will act as technical advisor to fire fighting personnel.

4. AREA CONTAMINATION

Evacuate the contaminated room and minimize the movement of personnel into other clean areas so as to control the spread of contamination. Re-entry into the accident area and subsequent decontamination measures will be contingent upon recommendations of the Health Physicist.

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INTRODUCTION

1. General

This manual is intended to serve as a guide to Laboratory personnel in work operations involving radiation or radioactive materials and as general informational material concerning the Laboratory's radiological safety program.

2. Laboratory Policy

The basic principles of radiological safety operations are:

a. Radiological safety is a responsibility of the individual. Every employee must know the radiological safety aspect of his normal duties and perform these duties in a manner that will assure the safety of himself and others.

b. Every supervisor is responsible for the safety of the operations under his control.

c. Each Division will be responsible for its own radiological safety. Division Heads will review the work practices of personnel under their supervision to assure that they are adequate.

d. Radiation and contamination will be confined at the source insofar as practical. Radiation and radioisotope sources will not jeopardize other users, either from the point of view of health protection or the conduct of experiments. Non-radioactive tracers will be used wherever possible, particularly in connection with aerosol transport and distribution problems. Engineering-scale test, effectiveness, and evaluation projects, as well as radiation shielding and scattering experiments which require full-scale structures and sources of greater than 10 curies in the open and unconfined will be conducted at an Engineering Field Test Station.

e. The Health Physics Division will act as an audit and advisory agency to the Laboratory in all matters of radiological safety. It will provide consultation and monitoring service wherever requested, and will carry out routine monitoring and inspections sufficient to guard against personal overexposure and against increase of radiation background that would interfere with measurements.

f. Radiation exposure, at any level, should be incurred only if there is a valid necessity for such exposure.

3. External Guides

The Laboratory obtains and uses radioactive materials under licenses granted by the U. S. Atomic Energy Commision. Under these licenses, the

Laboratory is subject to inspection and control requirements as outlined in the Code of Federal Regulations, Title 10. Certain prohibitions are specified. For instance, radioisotopes may not be used in or on humans unless a specific license permitting that use is obtained. Certain radioisotopes and quantities of radioisotopes may not be brought on board unless specified in a license. For information concerning the scope and limitation of licenses held by NRDL, the Health Physics Division should be contacted.

SECTION I

REGULATIONS AND PROCEDURES FOR WORKING WITH AND HANDLING RADIOACTIVE MATERIALS

1. Rad-Safe Procedures

a. Zone Precautionary Measures

(1) Zone Designations. Laboratory areas are divided into four zones, as follows:

Zone 1 - Radioactive Material not Permitted. Examples: cafeteria, auditorium, offices on the 3rd floor, escalators, etc.

Zone 2 - Background Control Required. Examples: counting rooms, film storage and developing areas, laboratories for radiochemical urinalyses and tracer studies. Contamination control procedures required and must be formally documented.

Zone 3 - Radiation Area. Examples: work areas where radioactive material may be handled routinely.

Zone 4 - High Radiation Area. Examples: work areas in which the radiation level is such that a major portion of the body could receive greater than 100 mrem/hr; work areas in which an aerosol greater than 10 times the RCG is generated. Dosage and contamination controls are required and must be formally documented.

Supervisors will determine the zone level of all work areas under their control, with advice from personnel of the Health Physics Division, Code 730, as necessary.

A chart showing the zone level of all NRDL work spaces will be maintained and posted in the Code 730 office.

(2) Zone Markers. The zone number will be conspicuously posted for Zones 2, 3, and 4. ANY SPACE THAT DOES NOT DISPLAY A ZONE NUMBER SHALL BE CONSIDERED A ZONE 1 AREA. Zone markers will be standardized by Code 730 and posted by the Engineering Division, Code 240, in accordance with the information provided by the appropriate supervisor.

b. Contamination Control

Use of radioactive materials presupposes the potential spread of contamination between contaminated and clean areas by the movement of personnel and equipment. The following controls are established:

(1) Personal Protection. No eating, smoking or drinking should be done in spaces where radioactive material is used or stored (Zones 2, 3, and 4). Nothing whatsoever shall be put into the mouth, this includes pipettes and stems of wash bottles.

All open cuts will be covered before working with radioactive materials.

Gloves will be worn when handling objects that may be contaminated.

Protective clothing or equipment will not be taken into any area where food is stored, prepared or eaten. Protective clothing shall not be worn in the cafeteria.

Food containers or utensils of any kind will not be used for storing or handling radioactive materials.

A careful self monitoring survey will be made on all personnel after work with radioactive materials in quantities in excess of those listed in Appendix C, no matter whether they are leaving for lunch, rest periods, or leaving the premises.

(2) Use of Protective Clothing. Protective clothing requirements shall be specified by supervisor for all operations involving radioactive material. Contaminated clothing shall be removed at point of egress from contaminated area.

(3) Zone Control. The movement of personnel and equipment from contaminated to clean areas shall be controlled or placed under stated restrictions.

(4) Storing and Handling Radioactive Materials. Operations with radioactive solutions in quantities in excess of those listed in Appendix C, Reference 2, shall be conducted in a tray or basin of sufficient capacity to hold all the solution if spilled.

Solutions shall be in containers unlikely to be broken or to spill. For high activity levels, the container shall have a secondary container or catchment under or around it. Caution shall be exercised in handling radioactive liquids in the laboratory. Work areas (bench tops, hoods, etc.) must be covered with absorbent material. Liquid samples carried between rooms must be in closed, non-breakable containers or else in a container surrounded by a secondary non-breakable container with absorbent material sufficient to take up the entire sample if spilled.

Samples for counting shall not be carried to the counting room in hands or instruments that have not been monitored and proven free of loose contamination. Samples must be carried in trays or the like to obviate getting any on the floor, etc.

Glassware known to be contaminated will be rinsed in the laboratory where it is used, to remove the major part of the activity. It will be segregated when sent to the glass washing shop for cleaning. Water used for washing and rinsing shall be regarded as contaminated waste and disposed of as such.

No radioactive material shall be transported via the escalators.

No contaminated materials shall be taken into machine shops or other service areas, unless specifically designated as an area for working with contaminated materials.

Movements of radioactive materials external to NRDL (e.g. over the State Highways) will be in compliance with California State regulations. A check should be made with the Health Physics Division to ensure that all items of compliance are met (see Section 3.1 E).

(5) Waste Disposal. All radioactive materials for disposal will be placed in waste containers provided. NEVER USE THE SINK. Waste solutions and solids containing alpha emitters will be placed in cartons and sealed with polyethylene before placement in containers. Special carboys will be used for organic liquids. Dead animals, which contain radioactive material, will be put into plastic bags, formaldehyde will be added, and the sealed bags placed in a 20 gallon can. (See Section 3.2 B.)

c. Special Precautions for Radiation and Contamination Control

Many of the Laboratory's radiation sources and particle accelerators produce levels of such magnitude that personnel exposed for even short periods of time might well receive serious radiation doses. Special safety systems and operating procedures are necessary to prevent inadvertent exposure. Such procedures shall be approved by the Division and Department Head concerned and forwarded to the Radiological Safety Committee for their review and recommendation.

(1) Radiating Machines. Flashing light and/or sound alarm systems which are automatically activated when the machines are turned on shall be installed on all radiating machines. Door interlock systems to prevent entry into the radiation field when the machine is in operation are mandatory. Special operating procedures shall be properly documented and posted to serve as an aid in preventing accidental exposure.

(2) Sealed Sources. All radiation sources greater than 1 curie shall be delineated with permanent type barriers. Warning signs will be posted and flashing light systems will operate when the source is exposed. Procedures shall be properly documented and posted to serve as an aid in preventing accidental exposure.

(3) Contaminated Areas and Equipment. The zone level of all work areas will be determined by the supervisor and suitable signs posted to indicate

the zone level and special precautions that are necessary. The Health Physics Division will mark work areas where more than 10 body burdens of radioactive material are handled with a sign indicating the approximate quantity and type of radioactive material present in the area. Zone 4 areas will be roped off or barricaded. Signs will be posted to indicate the radiation hazards present.

All contaminated equipment, including vehicles, will be tagged with contamination tags that clearly indicate the extent and location of the contamination. These tags will remain on the equipment until the Health Physics Division has determined that they are no longer required.

(4) Aerosols. If aerosol production is possible, or radioactive vapor or gas is involved, the material shall be transferred and operations carried out in a fume hood or if above RPC levels in a glove box. Heating of containers that hold radioactive material shall be done in a pan or tray to catch material, if spilled, and should be done in a fume hood even if material is considered non-volatile.

Table 4.4, Volume II, Reference (a) defines the requirements for respiratory protection in relation to the level of concentration of activity of airborne contamination.

(5) Control of Field Operation Samples and Equipment. The regulations for the control of movement and storage of Field Operation samples and equipment will be prepared by the Logistics Support and Health Physics Divisions and submitted to the Commanding Officer and Director via the Radiological Safety Committee for review and approval.

(6) Criticality Precautions. Special precautions are required to insure against the inadvertent accumulation of a sufficient quantity of special nuclear materials (U^{233}, U^{235}, Pu^{239} or other fissionable material) to create a critical mass with an attendant nuclear chain reaction.

Two types of configuration will be considered. The first will be unsealed quantities of special nuclear material. For the purposes of this manual, a "unit" will be defined as 250 grams of any unsealed special nuclear material.

Only one unit may be used in a room at any time. No quantities of unsealed special nuclear material greater than one gram may be used in rooms adjacent to a room where a unit is being used. In no event will the buffer distance be less than 12 feet. The Health Physics Division, Code 730, must be notified in advance before gram quantities of unsealed special nuclear material may be moved from any room. Gram quantities of special nuclear material not in use should be stored with the Health Physics Division.

The second type of configuration will be as "sealed sources" containing more than 250 grams of special nuclear material. The "sealed source" configuration must meet the criteria established in TID-7016, "Nuclear Safety Guide" for

sub-criticality by virtue of quantity, size, volume or dimension before procurement or use in the Laboratory. In addition, the basic configuration of the sealed source shall not be altered in any way during use and additional quantities of special nuclear materials shall not be used or stored in the same or in adjacent rooms.

(7) Tritium

(a) Precautions. Precautions to be taken when working with tritium or tritium-contaminated materials in quantities in excess of one millicurie include the wearing of rubber gloves and the use of glove boxes or hoods. Rubber gloves should be worn and changed frequently, since tritium water vapor passes through the rubber in hours or less. All equipment which has come in contact with tritium, either gas or T_2O vapor, will retain some tritium and should be considered contaminated. Stopcock grease, vacuum pump oil, and plastics are readily contaminated, whereas, materials such as glass or stainless steel retain smaller quantities. At ordinary room temperatures, the diffusion of tritium through glass or stainless steel or from tritiated accelerator targets is negligible. Tritium losses from targets may result from heating or by an exchange mechanism when in contact with ordinary hydrogen. Such targets must always be handled with rubber gloves, as quantities up to several curies per square centimeter of target surface may be absorbed on the target. Deuterium targets should also be handled with gloves, since tritium contamination of several microcuries may also be present.

Tritium contamination is so often associated with vacuum pumps that special precautions must be observed when disassembling or repairing a pump that has been used on a system containing tritium. Oil and mercury associated with the pumps should be carefully checked.

(b) Monitoring. All personnel working with tritium shall submit, periodically, urine samples for body uptake checks. Code 730 will advise the frequency of monitoring. All areas in which tritium is used in quantities in excess of one millicurie and especially vacuum pumps for systems containing tritium, should be monitored for absorbed surface tritium by health physics personnel. It must be remembered that the ordinary portable beta monitoring instrument will not detect tritium due to the very short beta particle range. Air monitoring instruments capable of detecting tritium are available and should be used when there is the possibility of release of tritium to the atmosphere.

Two instruments presently used to monitor radioactive gas are the T-289 and T-290 radiacs. These instruments measure the rate of ionization produced by radioactive gases in the surrounding air. Air drawn into the radiac - passes through a precipitation chamber, which removes the free ions. The air then enters the ionization chamber which detects ions due to radioactive decay of gas. The limit of detection of the T-289 and T-290 is approximately 1×10^{-6} $\mu c/cc$ and 1×10^{-4} $\mu c/cc$, respectively.

Another method for monitoring tritium, which associates itself with the moisture in the air, is the "cold strip method". The method consists of a metallic strip immersed in a liquid nitrogen bath and extending well into the atmosphere to be sampled. Moisture condenses on the upper part of the cold strip. When the liquid nitrogen is completely exhausted, the ice melts and is collected in the Dewar flask. The specific activity of the tritium in aqueous sample is then calculated. The limit of detectability of this method is approximately 1×10^{-9} μc/cc.

(8) Plutonium. There are three main hazards to the use of plutonium. These hazards are criticality, pyrophoricity, and its high toxicity.

(a) Criticality. Criticality is the condition when fissionable material (i.e. U^{235}, U^{233}, Pu^{239}) is capable of sustaining a chain reaction. All of the deaths attributed to nuclear energy in the nuclear industry had been derived from an unplanned criticality. This is why criticality is such an important factor in the use of fissionable material.

(b) Pyrophoricity. Plutonium metal, especially in a finely divided state, is capable of spontaneous ignition. Plutonium hydrides and metallic alloys of plutonium are also pyrophoric. This property and an installed automatic fire smothering system should be considered, whenever gram quantity of solid plutonium is contemplated for use.

(c) Toxicity. Plutonium is one of the most hazardous radioactive elements known today. The long effective half-life and its alpha emissions had produced neoplastic growth in the bone tissue of lower animals. In man, the recommended permissible body burden for the bone is 0.04 μc, which is 2.5 times more restrictive than radium.

The easiest method of entry into the human body is via contaminated air. Proper design of the experimental apparatus and good housekeeping is the first step towards aerosol control. After the project had been initiated, air and surface monitoring should be performed regularly. All solutions of plutonium must be covered, when not in use.

Experiments regularly handling greater than one millicurie (16.2 mg) of plutonium should be done in a glove box. An enclosed system within the glove box should also be used as much as possible. It is imperative that no leakage of plutonium into the laboratory spaces be tolerated in Building 815. If the plutonium escapes into the laboratory and contaminates the ventilation system, the system will have to be shut down. This will necessitate evacuating the building until the system is decontaminated, which might run into months.

Another method of entry is via contaminated wounds or breaks in the skin. It is surprising the number of times one encounters reports of workers whose digits were punctured by plutonium chips or whose bare hands were in contact with high acidic solution of plutonium. Once the material is present in the subcutaneous tissue, the area will slowly but continuously release

dosimeters are checked daily, and if a high reading is indicated, the film badge will be processed immediately to substantiate the chamber reading. Radiation as measured by pocket chambers will be used as a guide only and will not be incorporated in the permanent record.

(c) Individual Responsibility. Each individual employed in the Laboratory shall wear his identification film badge at all times while in the Laboratory. The badge shall be worn on the chest or collar. If a badge is inadvertently left in a radiation field, the individual shall retrieve it as soon as possible and must notify the Health Physics Division of the circumstances related to the exposure. Film badges must not be carried away from the SFBNS areas of NRDL, and employees are especially cautioned not to wear them when receiving medical X-ray or radioisotope diagnostic examination and/or treatment.

(d) Visitors. All visitors to NRDL facilities, including contractors and their employees, will wear film badges, except escorted visitors to Zone 1 areas of Building 815.

(2) Radiation Received Away from NRDL. Radiation doses received from outside the Laboratory shall also be included on each individual's record.

(a) Work at Other Activities. Each Branch Head shall notify the Health Physics Division when work involving radiation is to be done at other activities. If the dosimetry is accomplished by the other activity, the results will be returned to the NRDL Health Physics Division for inclusion in personnel dose records. If dosimetry is not available at the other activity, special film badges will be furnished and processed locally. (NOTE: NRDL film badges will be worn during work away from this activity only when prior arrangements have been made by the Health Physics Division.)

(b) Field Operations. Doses received by NRDL personnel at field operations will be officially reported by the Test Command to the Laboratory for inclusion in personnel records.

(3) Internal Contamination. The Radiological Health Officer will initiate all requests for radiochemical analyses, interpret results, recommend corrective action, and maintain personnel exposure records. The Health Physics Division will investigate positive results and aid in evaluation of findings. The total urinary output over 24 hours shall be collected and an analysis made for radioactivity.

(a) On each employee upon hire and upon termination.

(b) On any person known to have been exposed to ingestion, inhalation, or absorption of radioactive materials.

(c) Periodically, on personnel who routinely work with radioactive materials.

(d) On personnel engaged in field operations both prior to and upon return from the operation.

(4) Personal Contamination. In the event that any person is contaminated in excess of the lowest levels specified on page 16, the Health Physics Division shall be contacted immediately. A complete monitoring survey will be made to evaluate the extent of the contamination. Significant levels will be recorded on NRDL Form 12ND NRDL-342, Special Monitoring Report. The Health Physics Division representative will provide the necessary assistance to ensure complete decontamination. The degree of decontamination achieved and the final contamination levels will be recorded on the Special Monitoring Report. If the occasion warrants, an accident report shall be prepared as indicated in Section 1.5 A.

(5) Notification of Exposure

(a) Immediate notification of exposure in excess of the limits prescribed in Section 1.5 will be given the individual and his supervisor by Code 730.

(b) Information as to radiation exposure of an individual will be provided to the individual or his supervisor whenever requested.

(c) Following termination of employment at NRDL, the individual's radiation exposure record will be made available only upon his request.

b. Environmental Monitoring

(1) Routine Monitoring. A periodic monitoring program will be conducted at the discretion of the Health Physics Division. This includes, at various locations in the immediate geographic area, the measurement of radiation, liquid effluents being discharged to the public sewer system, and air effluents escaping from or being found outside the building. The Health Physics Division will recommend corrective measures for any contamination disclosed as a result of this program.

(2) Special Monitoring. Special monitoring surveys shall be made by the Health Physics Division and recorded as follows:

(a) Radiological clearance of equipment or areas.

(b) Contamination levels after decontamination operations.

(c) Radiation and contamination levels in connection with specific experiments.

(d) Special Work Permits.

(e) New equipment or building alterations that might change existing radiation contours.

Results of these surveys shall be reported on NRDL FORM 12ND NRDL-342, Special Monitoring Report, and permanent records will be made of all significant results. The Health Physics Division will evaluate the significance of any contamination and recommend corrective action.

3. Medical Examinations

The Radiological Health Division shall maintain a record of radiation dosage received by every person in the Laboratory. (Record of Exposure to Ionizing Radiation, Form DD-1141.) The records will be reviewed at regular intervals by the Radiological Health Officer to ensure that no one has received more than the MPD for a given period. The examinations and analyses shall be performed as indicated below.

a. Laboratory Operations

(1) Radiological Health Examinations. Upon reporting for work at the Laboratory, and upon termination of employment, each person will receive a radiological health examination in addition to the regularly required physical examination.

(2) Radiochemical Urinalysis. The Radiological Health Officer will obtain radiochemical urinalysis on the following:

(a) New Employees. A sample shall be obtained from each new employee at the time of his pre-employment physical examination.

(b) Termination of Employment. A sample shall be obtained from all employees upon termination. While such sampling shall be considered a part of the termination physical examination, it is preferred that it be submitted sufficiently prior to the last work day so as to permit analysis before the employee departs and for the results of analysis to be available to the examining physician at the time of termination of physical.

(c) Field Operations. Samples from NRDL personnel participating in field projects shall be submitted sufficiently prior to subject operation as to permit analysis before orders are issued. Field projects or any activity involving radioactive materials or radiation sources away from NRDL or Camp Parks. A post-operation sample shall be submitted upon completion of the field operation. Where possible, such sample will be collected at the test site at a time immediately following the last event in which the individual participated. Personnel not regularly assigned to field projects, who visit

test sites, shall be sampled in the same manner as full participants. Responsibility for all personnel reporting to NRDL Dispensary prior to departure for field projects and on return from field projects shall rest with the head of the department.

(d) Radiological Accidents. Each person, whether employed by NRDL or not, who is involved in a radiological accident on NRDL premises or at a NRDL administered field operation will, at the discretion of the Radiological Safety Officer or Health Physics Division and approval of the Radiological Health Officer, submit a sample immediately after such an occurrence. An accident is a spill or any contaminating event in which there is a possibility of assimilation of radioactive material in the body.

(e) Routine Sampling. Routine sampling, as ordered by the Radiological Health Officer, will be performed annually upon personnel using radioactive materials in pursuance of normal duties, and upon personnel working in spaces where such materials are used routinely. Tritium sampling shall be done weekly on all personnel using tritium in quantities in excess of the levels listed in Appendix C, Reference 2.

(f) Sampling for Activities Other Than NRDL. Requests for radioassay of biological samples received from other DOD activities will, upon approval by the Radiological Medical Director, NRDL, be processed in accordance with the procedures under Section 3 below. The Radiological Health Officer will prepare answering correspondence for the signature of the Radiological Medical Director.

(g) Follow-Up Sampling. Additional sampling will be accomplished, as required by the situation, at the discretion of the Radiological Health Officer as a recommendation by the Health Physics Division.

(h) Legal Release. When an individual declines to submit a properly requested specimen, he shall be required to sign a statement releasing the Laboratory and the Navy of legal responsibility.

(3) Special Examinations. The Radiological Health Officer will perform special examinations, as indicated below, upon the following:

(a) Any employee who developes an acute, unexplained illness of more than three days duration.

(b) Any person who has received an acute radiation exposure (from any source) in excess of 25 rem, or a chronic radiation exposure (from any source) of 75 rem if accumulated within a period of less than five years.

(c) Where a person is expected to be exposed to significant neutron or microwave radiations, a special eye examination shall be conducted prior to assignment of such duty, semiannually, and upon termination of employment.

b. Field Operations

(1) All Laboratory personnel participating in field operations will receive a physical examination, including a radiochemical urinalysis. Specific instructions will be issued prior to each operation by the Radiological Health Officer.

(2) If, during a field operation, any person is subjected to an exposure in excess of the established RPG, he will report to the Radiological Health Officer for a complete physical and clinical laboratory examination, including a radiochemical urinalysis, immediately upon termination of participation in the operation.

c. Visitors in Work Status

Medical surveillance may be required for certain visitors who may be subject to occupational exposure to radiation while within NRDL jurisdiction. Work status visitors may include military personnel from other installations, contractor personnel, students, or other persons performing work on an invitational, uncompensated basis.

Any individual working with radioactive materials within Laboratory premises or jurisdiction shall be required to undergo radiological health examinations as provided in Paragraph 3.a. of this manual. Also, any individual working four successive weeks or more in laboratory areas where exposure to ionizing radiation is possible (e.g. first, fourth, fifth, or sixth floors of Building 816 and 820, or certain areas of Camp Parks) shall undergo radiological health examinations.

The applicable division head (Code 908 for OCD contractors) will notify the Head, Radiological Health Division (Code 720), of those visitors who, as defined above, will require radiological health examinations. Such notification should precede the visit and should include the dates of the visit. The Medical Director, Code 700, will decide those cases in which doubt exists as to whether or not a given visitor will require radiological health examinations. The Camp Parks representative, Code 170, will assure through contact with the Medical Director, that Camp Parks visitors have received radiological health examinations where required.

4. Radiation Protection Guides (RPG's)

a. Definitions

(1) Radiation Protection Guide (RPG). The radiation dose which should not be exceeded; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable.

(2) Radioactivity Concentration Guide (RCG). The concentration of radioactivity in the environment which is determined to result in whole body or organ doses equal to the Radiation Protection Guide.

b. Dose Limits

(1) General. Subject to exceptions in Paragraphs 2 and 3 below, the occupational whole body dose limit for Laboratory operations is 1.25 rems per calendar quarter.

(2) Special Operations. When required by the nature of the NRDL experiment, an individual may be permitted to receive a whole-body dose greater than 1.25 rems per calendar quarter provided: (a) the exposure shall not cause the individual to exceed 3.0 rems in the particular calendar quarter, (b) the exposure shall not cause the individual to exceed an accumulative lifetime dose equal to (N-18) x 5 rem (N being the individual's age); and (c) the operating supervisor previously ascertains that the individual has a documented exposure history on file with the Health Physics Division, Code 730.

(3) Minors. The dose limit for individuals under 18 years of age is 0.125 rems per calendar quarter.

c. Internal Contamination

The RCG's for radioisotopes entering the body from any process are listed in Volume 2, Appendix A, Part 1 of Reference (1) as MPBB's (maximum permissable body burdens). Body excretion rates resulting from MPBB's are listed in Volume 2, Table 4.5 of Reference (1). Laboratory operations will be conducted in such a way that internal contamination will be kept to a minimum.

d. Surface Contamination

The RCG's for surface contamination are listed as follows:

ISOTOPE	AVERAGE	MAXIMUM	REMOVABLE
Alpha Emitters	500 d/min-100 cm^2	1,000 d/min-100 cm^2	20 d/min-100 cm^2
Beta-Gamma Emitters	0.2 mrad/hr @ 1 cm	1.0 mrad/hr @ 1 cm	200 d/min-100 cm^2*

*For tritium, the removable limit is 10,000 d/min-100 cm^2

e. Air and Water Contamination

The RCG's for exposure of NRDL personnel to breathing air and drinking water are listed in Appendix B, Table I, Reference (2). The RCG's for air and water contamination for release from Laboratory control to the environment are listed in Appendix B, Table II, Reference (2).

5. Radiological Reports

Actions to be taken in emergencies are presented at the beginning of this instruction. In this connection the following reports are mandatory:

a. Accident Reports

(1) Preparation. Not later than 48 hours after the accident, the following will prepare and forward a written report, to the Chairman of the Radiological Safety Committee:

(a) The Head of the division involved in the accident. A report on the condition at the time of the accident, its probable cause, safety controls used, personnel involved, and degree of injury, if any, and immediate action taken. (Copies to Codes 905, 730, and 720.)

(b) The Head, Health Physics Division. A statement of the action taken by his group, analysis of the circumstances of the accident in order to determine error in procedure, and recommendations for prevention of similar accidents. (Copies to Codes 905, 720, and Division Head involved.)

(2) Review. The Radiological Safety Committee will study the reports, evaluate the hazards of such an accident, and recommend a course of preventive action. The Chairman, Radiological Safety Committee will attach the comments of the committee to each report and forward one copy of each to the Director and the Department Head concerned. Reports will be sent to distribution outside the Laboratory in accordance with instructions supplied by the Bureau of Medicine and Surgery and as set forth in the AEC authorization to NRDL to procure and handle by-product materials and special nuclear materials.

b. Radiological Overexposure Reports

Currently the permissible level for exposure to whole body radiation, as set forth in the Code of Federal Regulations, Title 10, Part 20, is 1.25 rem/quarter of penetrating radiation (deep dose) or 7.5 rem/quarter of non-penetrating radiation (surface dose). For the usual four week badging period, these levels would be 0.4 rem/4-week period and 2.5 rem/4-week period, respectively. Film badge exposures greater than these are considered to be in excess of that permitted for safe continued practice. Additional information on radiological exposure limits may be found in Section 1.5. Instances of overexposure as revealed by the film badge program will be investigated and reported in full particulars to the Radiological Safety Committee. The Committee will review the incident, determine the extent of the biological significance, and make recommendations for corrective action.

SECTION II

RADIOLOGICAL SAFETY EQUIPMENT

1. Protective Equipment

a. Clothing

Control of radioactive contamination requires the use of protective clothing to eliminate body contact with the contaminant and the spread of contamination to clean areas. Ordinary clothing provides some protection; however, the greater the body area covered, the larger the degree of protection achieved. Penetrability, durability, and ease of decontamination are important in the choice and use of protective clothing. The following items are available:

(1) Fine weave coveralls or laboratory coats for most laboratory operations.

(2) Gloves (surgeon's rubber, cotton, leather, or heavy rubber, depending on the job) to minimize hand contamination.

(3) Shoe covering (plastic booties, rubber boots, or rubber overshoes as required) where potential floor or ground contamination exists.

(4) Respiratory protection (such as Army Assault Mask or Navy Mark V mask) where there is danger of airborne contamination.

(5) Hoods (made of plastic or fine weave canvas) under appropriate conditions.

Protective clothing requirements for all operations in Zone 3 or 4 areas must be specified by the supervisor. The Health Physics Division representative assigned to each Division is available for advice on such matters.

b. Shielding Materials

The term "shielding materials" as used here includes all materials used to construct temporary shields or caves. Lead and concrete blocks are most commonly used in the Laboratory. Lead bricks are available in two-inch thicknesses of such size and shape to permit convenient handling and stacking in the formation of interlocked walls and caves.

c. Issue and Control

(1) Clothing. Issue of protective clothing originates with the individual who submits the appropriate request form, with the knowledge and approval of his supervisor to the Logistics Support Division at the NRDL Clothing Decontamination Facility. For most normal continuing type work done locally, the

NRDL Form 75, Protective Clothing Issue Card, Supplies. For special work or one time situations, the Special Work Permit, NRDL Form 93, can be used for clothing issue.

(a) All items issued will be returned after use or for exchange to the NRDL Clothing Decontamination Facility, where they will be decontaminated or placed in stock as appropriate. Used items are monitored by Logistics Support Division under the technical supervision of the Health Physics Division. If contamination is found, it is reported to the Health Physics Division on NRDL Form 290, an investigation is made and corrective measures are recommended.

(2) Shielding Materials. One completed copy of NRDL Form 61, Request for Lead Bricks, will be forwarded to the Logistics Support Division via the Health Physics Division. The bricks will be delivered to the requester by the Logistics Support Division. When the bricks are no longer needed for protection against radioactive materials, the Health Physics Division will be notified and arrangements will be made for the bricks to be checked for contamination, decontaminated if necessary, and returned to stock.

(3) Control. The Health Physics Division will act as an advisory agent on the procurement, use, removal, and disposal of protective clothing, shielding materials, handling equipment and instruments.

2. Remote Handling Equipment

Work with radioactive material requires control and confinement of loose activity. For this purpose a stock of remote handling equipment, as listed below, is maintained at the Laboratory. It is the responsibility of the individual to requisition these facilities for the program in question. Health Physics Division personnel will advise on the procurement and use of the items as necessary. The following items are available for use at NRDL: (a) glove boxes, (b) enclosed work spaces or restricted rooms (Room 1109), Building 131 at Camp Parks are available for work with large quantities of radioactive materials, (c) temporary shielded areas constructed of lead bricks, concrete, etc., (d) tongs, and (e) master slave manipulators for use with very high levels of activity in hot cells.

3. Radiation Facilities

The Health Physics Division should be notified of the design features of any facility that is to be used for handling radioactive material. The prevention of personnel overexposures and aerosol releases during the course of any experiment can be accomplished through a review of the features of the facility by a Health Physicist.

Experimental facilities that are proposed for the use of radioactive material will be approved for adequacy of shielding, adequacy of aerosol control and adequacy of radioactive materials handling.

Proposed experimental plans that are submitted via the RDL Form 44 or 44A will be reviewed by the Health Physics Division for adequacy of structure to provide safe conduct of the experiment.

4. Monitoring Instruments

Monitoring instruments are essential tools in a radiological safety program. The variety of types and levels of radiation requires a wide range of instruments as to both model and quantity. There are a number of fixed installation instruments in the Laboratory (such as hand and shoe counters, continuous aerosol monitors, laboratory-type counters, etc.) as well as a supply of portable instruments.

Portable survey meters are divided into two general classes: contamination meters which are used to detect and estimate quantity of radioactive contamination, and dose rate meters which are used to measure radiation levels. A third class of instrument includes the counting and sampling devices. Portable instruments of all three types are available for use by the investigator and are maintained at the Central Instrument Pool for issue or replacement. Representatives from the Health Physics Division will aid and advise in the use of portable instruments as required.

5. Dosimetric Devices

Dosimetric devices include all types of instrumentation used to measure the accumulated radiation dose received by personnel. These are worn for stated intervals and then processed to determine accumulated radiation exposure. The doses are recorded and constitute the individual's legal dose record, upon which participation in and time limitations of future radiological work are based. Two types of personnel dosimeters are used at NRDL: film badges and pocket ionization chambers. Film is processed by the Health Physics Division, pocket chambers are issued by Code 243D upon recommendation of a health physicist, or as required in b below.

a. Film Badges

The NRDL badge is a plastic multifiltered film holder (with lead, aluminum, and cadmium shields) which contains a two-film packet (10 mrad to 10 rad and 5 rad to 1,000 rad). This badge is designed to serve also as a security badge and must be worn at all times by every Laboratory employee when in NRDL Buildings, even when in non-radiation areas. A separate film, also inserted into the plastic holder must be worn by all those personnel who work with neutron sources.

b. Pocket Ionization Chambers

Pocket chambers are used to supplement film badges in high exposure or short term work, since they provide an immediate indication of accumulated dose. While the chamber is used for dose control during a specific part of an

operation or experiment, the film badge is the final arbiter as to the amount of radiation actually received, and the film badge dose is entered upon the legal record.

Self-reading pocket dosimeters must be worn by all personnel who are present in a high radiation area (Zone 4).

SECTION III

ACQUISITION, CONTROL AND ACCOUNTABILITY OF RADIOACTIVE MATERIALS

1. Licensing Requirements

NRDL's AEC licenses provide certain limitations on the procurement, possession and use of radioisotopes. Some of these limitations are: (a) Radioisotopes may not be used in or on humans unless a specific license permitting that use is obtained. (b) NRDL is licensed to possess and use specific radioisotopes and quantities of these radioisotopes. Radioisotopes obtained in the regular procurement channels are screened for license compliance by the Health Physics Division. Any procurement outside the regular channels should be cleared with the Health Physics Division. (c) Radioisotopes may not be used at any location other than NRDL facilities except under limited conditions. Such proposed use should be cleared with the Health Physics Division. (d) Radioisotopes may not be transferred except to an activity licensed to receive the material.

2. Radioisotope Procurement

a. Determination of Requirements

A Scientific Investigator planning an experimental program involving the use of radioactive materials will determine the type and quantity of radioisotope or material required, the radiological safety equipment and the procedures necessary for safe conduct of the experiment. The Health Physics Division representative assigned to each division is available to assist and advise experimental investigators in the determination of requirements.

b. Request for Approval

The experimental investigator in the Scientific Department will submit the pertinent information on Radioisotope Use Approval Form, 12ND NRDL-44, prepared according to the instructions shown on the form, through his Divisional Office, to the Chairman, Radiological Safety Committee. The Associate Scientific Director will act as Division Head for investigators who are not members of the Scientific Department and are requesting radioactive materials for use at this Laboratory. Reorders or amended uses of isotopes for use in established experiments shall be initiated on Radioisotope Information Form 12ND NRDL-44A, a simplified version of the Form 12ND NRDL-44.

c. Radiological Safety Committee Review

The Use Approval Form 12ND NRDL-44, as prepared and submitted in b above, shall be reviewed by the Divisional Office, and forwarded to the Health Physics Division for review and a statement of the radiological safety requirements for the experiment shall be attached to the request on a Form 12ND NRDL-76, Health Physics Division, Isotope Procurement Investigation.

It will then be submitted to the Chairman, Radiological Safety Committee, who will review it and, if, in his opinion finds the radiological safety controls to be adequate, will authorize the use of the material as indicated on the form.

d. Ordering of Materials

After approval of the Radiological Safety Committee has been received:

(1) Using Division. (a) Will prepare the stub requisition (Request for Issue or Turn In, Form DD 1348-1, and special instructions or correspondence. All stubs will specify delivery via Code 730. (b) Will route all requests to Code 730, through normal channels.

(2) Health Physics Division. (a) Will review the request for conformance with safety and license requirements. (b) Will record necessary data to maintain the central record of all radioactive materials at the Laboratory. (c) Will initial or otherwise signify its review of Form DD 1348-1, detach copy for its records, and forward the request for processing through regular supply channels.

e. Receiving and Shipping

The Logistics Support Division shall receive all shipments of radioisotopes and shall deliver them to the Health Physics Division. Health Physics personnel will inspect the shipment, monitor the contents, and store the item until needed by the scientific investigator. Aliquots of materials may be withdrawn from the stores and delivered to the scientific investigators under the supervision of the Health Physics Division personnel.

Special attention shall be given to all orders involving shortlived isotopes (T-1/2 less than 24 hours). All stub requisitions for such material shall be specially marked by the Health Physics Division to assure prompt notification of the investigator upon arrival of the shipment.

The receipt of any radioactive isotipes or material specially irradiated, not involving the action of the Logistics Support Division, shall be handled directly by Health Physics Division personnel.

All shipments of radioactive materials from the Laboratory will be made under the supervision of the Health Physics Division. Code 730 will make the necessary check to ensure compliance with the Interstate Commerce Commission, AEC, and all other regulations. Provisions of Tariff No. 8, Interstate Commerce Commission Regulations, Sections 73.391-4 and 73.414 apply.

3. Accountability and Control

The possession of radioisotopes, by-product material (radioisotopes with atomic numbers between 3 and 84, inclusive), and special nuclear materials

(those used in this Labo[illegible]y are hydrogen 3 (tritium), [illegible]um 232, uranium 233, uranium 235, uranium 238, and plutonium 239) is controlled by licenses issued by the Division of Licensing and Regulation, AEC. The license requires the holder to maintain accurate inventories of materials and to conform to AEC regulations concerning disposal and transfer of the materials.

a. Accountability (physical)

Physical accountability for radioisotopes, by-product materials, and special nuclear materials is the responsibility of the Health Physics Division, which maintains complete records on location and use as required by the AEC. Radiation sources will be inspected and leak tested as required. Required reports to AEC will be the responsibility of the Health Physics Division.

b. Waste Control and Disposal

The quantities of radioactive isotopes and other nuclear materials used in the Laboratory necessitate a uniform procedure for handling and disposal (final accounting) of such materials when they become waste. Radioactive waste includes all materials that are contaminated to the extent that release through normal disposal channels would be inadvisable when public safety is considered. The procedures used for radioactive waste disposal are intended to guard against contamination of laboratory spaces, shipyard facilities, and the public domain as well as to permit utilization of radioisotopes. In the collection of waste special nuclear materials, the procedures to prevent criticality as outlined in Section 1, c. (6) above will apply. Specially marked waste containers will be used for all special nuclear materials.

Laboratory scientific investigators will anticipate waste disposal problems as far in advance as possible and advise Plant Support Branch, Engineering Division as to the need for additional waste containers. The Engineering Division will dispose of the radioactive waste material for the Laboratory with the Health Physics Division acting to ensure compliance with radiological safety regulations. The Health Physics Division will monitor Laboratory waste containers at regular intervals, tagging containers with special radioactive waste shall be approved by the Division and Department Heads concerned and forwarded to the Radiological Safety Committee for their review and recommendation.

SECTION IV

RADIOLOGICAL SAFETY ORGANIZATION

The Radiological Safety Program of the Laboratory is established with the advice of the following:

Radiological Medical Director
Health Physics Division
Radiological Health Division
Radiological Safety Committee

This Program is administered through the line of Command.

1. Radiological Medical Director

The Radiological Medical Director is responsible for the radiological safety of the Laboratory. Specifically, he performs the following functions: (a) Advises the Commanding Officer and Director on all matters of radiological safety. (b) Directs and coordinates the activities of the Radiological Health and Health Physics Divisions. (c) Reviews all instances of radiological exposure in excess of the maximum permissible limits and prepares reports of such exposures for submission to the Bureau of Medicine and Surgery.

2. Health Physics Division

The Health Physics Division is responsible for the overall operation and supervision of the Laboratory's radiological safety program. Operating within the Medical Department, the division serves the entire Laboratory. Specifically, the functions of the Division are to: (a) Formulate radiological safety regulations for review by the Radiological Safety Committee. (b) Implement the radiological safety regulations and procedures as promulgated by the Commanding Officer and Director. (c) Provide continuous monitoring and consultative services to project leaders and scientific investigators with regard to optimum conditions for safety in the use of radioactive material. (d) Maintain and provide personnel dosimetry for all Laboratory personnel and visitors. Interpret and report results obtained from these devices and maintain permanent dosimetry records. (e) Review all requests for isotopes and irradiation services so as to assure the Radiological Safety Committee that the proposals conform to licensing requirements. (f) Keep a central inventory of all radioactive material in the Laboratory and store safely what is not in immediate use. (g) Be ready to assist in the procurement of special nuclear materials. (h) Insure that the disposal of radioactive waste is safe and meets legal requirements. (i) Measure and record the radiation levels and concentration of liquid and airborne radioactive materials being discharged both within the Laboratory boundaries and in the environs. (j) Review and make recommendations on the rad-safe aspects of all new facilities involving radiation machines or radioactive materials.

In addition to the functions mentioned above, the Health Physics Division assists in training and indoctrination of personnel in radiological safety and performs evaluation and developmental work in the field of health physics, with special emphasis upon Laboratory problems.

3. Radiological Health Division

The Radiological Health Division is responsible for all medical aspects of the radiological safety program of the Laboratory, and for the physical welfare of the Laboratory personnel insofar as it relates to Laboratory working conditions. Specifically, this Division (a) conducts pre-employment and terminal physical examinations of all personnel, (b) performs radiological health examinations, as required, (c) conducts a radiobiological assay program, including radioassay of samples from other DOD activities, (d) acts as liaison between the Laboratory and the SFBNS Medical and Dental Departments, (e) controls all records relative to radiological exposure of personnel and the interpretations of them, and (f) compiles and interprets data from radioclinical laboratory analyses in cases of possible internal contamination with radioactive material and recommends appropriate action.

4. Radiological Safety Committee

The AEC stipulates that, to be eligible for a license to procure radioisotopes and to possess source and special nuclear materials, an institution must establish a Radioisotope Committee (CFR 10, Part 30). The Radiological Safety Committee serves in this capacity at NRDL.

The Radiological Safety Committee reviews requests for isotopes and special irradiation, certifies that procurement is necessary to program objectives, that the facilities are adequate to handle the materials, and that the proposed method of usage is in accordance with accepted safe practices. In addition, the Committee will review policies and procedures for radiation safety, cases of exposures in excess of the RPG, and radiological incidents and will make appropriate recommendations to the Commanding Officer and Director. In addition, the Committee, with the support of the Health Physics Division, takes the necessary action to obtain and maintain licenses for the procurement of radioisotopes and for the possession of source and special nuclear materials.

The Radiological Safety Committee is composed of the following:

Chairman - Associate Technical Director, (Applied Studies), Alternate Chairmen - Radiological Medical Director and Head, Health Physics Division, Members - Head, Biological and Medical Sciences Division; Head, Nuclear Technology Division, Head, Radiation Physics Division, Head, Physical Sciences Division, Head, Technical Management Officer, three addition members, two appointed from the Technical Department and one from the Technical and Administrative Services Department.

5. References

a. Principles of Radiation and Contamination Control, NAVSHIPS 250-343-3.

b. Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation".

c. Radiological Health Protection Manual, NAVMED P-5055.